Don
Brown
435-750-1762

IM-1088-2

1200 Baud
No Parity
0/No Stop bits
8 data bits
No Flow Control

INSTRUCTION MANUAL

for the

HYGROTHERMOMETER

Model 1088

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Revision 2
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MC 1089
1088

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FOREWORD

The following is a listing of the major sections found in this manual, followed by a brief description of each:

Section 1 - General Information

This section contains a general description of how the system works and equipment reference data.

Section 2 - Operation

This section directs the operator in the use of the 1088 system. Turn-on procedures are explained as are methods of verifying the accuracy of output data.

Section 3 - Theory of Operation

This section explains how physical stimuli are measured electrically to determine the dew point and ambient temperatures. It gives a description of all hardware elements in the system.

Section 4 - Scheduled Maintenance

A periodic maintenance table is located in this section, as are all procedures necessary to perform routine, scheduled maintenance.

Section 5 - Installation

This section supplies information needed to prepare the installation site, a list of tools needed, installation procedures, and checkout procedures to verify accuracy of the instrument.

Section 6 - Schematics, Wiring Diagrams

Complete schematics with explanatory text are given for each assembly and subassembly. Wiring diagrams for the main units are also included.

Section 7 - Repair Notes

Repair instructions with pictorial guides are given for all routine repair, replacement, and service operations.

Appendices A & B

A software listing and a comprehensive parts list are found in this section.

SAFETY SUMMARY

The following are general safety precautions that are not related to any specific procedures and therefore do not appear elsewhere in this manual. These are recommended precautions that personnel must understand and apply during operation and maintenance.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must at all times observe all safety regulations. Do not replace components while the equipment is energized. Under certain conditions, dangerous potentials may exist when the power control is in the off position, due to charges retained by capacitors. To avoid injury, always remove power and discharge and ground a circuit before touching it.

RESUSCITATION

Personnel working with high voltages should be familiar with modern methods of resuscitation.

FIRST AID

Seek medical help immediately after injury. Any injury, however slight, should be treated.

TEST EQUIPMENT

Make certain test equipment is calibrated within required dates and is in good operating condition. If a test meter must be held, ground the case of the meter before starting measurement; do not touch live equipment or personnel working on live equipment while holding a test meter. Some types of measuring devices should not be grounded; these devices should not be held when taking measurements.

WARNINGS

A WARNING appears for an operating or maintenance procedure, practice, condition, statement, etc., which, if not strictly observed, could result in damage to or destruction of the equipment.

SECTION 1.

GENERAL INFORMATION

1-1. INTRODUCTION

This manual is intended for use by on-site technical personnel as a guide to installation, operation, and preventive & corrective maintenance of the Model 1088 Hygrothermometer.

1-1.1 Scope

This manual provides all information necessary to operate and maintain the Model 1088 Hygrothermometer.

1-1.2 Applicability

This manual is applicable to the Model 1088 Hygrothermometer, manufactured by Technical Services Laboratory, and to subassemblies of this model.

1-1.3 Warranty

Each instrument, including all parts, spare parts, and non-repairable subassemblies, is individually guaranteed against any noncompliance with this specification for a period of 180 calendar days after final customer acceptance of that system. Should any noncompliancy develop within the guarantee period, the noncompliant part(s) shall be replaced by the Contractor f.o.b. point of installation without expense to the customer.

All replaced parts, spare parts, equipment, and non-repairable subassemblies are covered under the provisions of this guarantee for a minimum of 30 calendar days in addition to the original guarantee period after receipt of that item by the customer at the point of installation.

1-2. EQUIPMENT DESCRIPTION

The Model 1088 Hygrothermometer is a climatic thermometer and dew point indicator developed by Technical Services Laboratory. It was initially developed as the Model HO83 for the National Weather Service and meets all of the requirements of NWS Specification HO83, dated 2/25/81. The system indicates dewpoint and ambient temperatures in the range of -80 to +130° F. Ambient temperature measurement accuracy is 1° RMS in the range of -60 to +122° F and 2 ° RMS through the remainder of the range. Dew point accuracy is 1° RMS above 32°. Below 32°, dew point accuracy varies with decreasing temperature, to a worst case of approximately 4° RMS. Resolution of display is 0.1°. The dew point instrument channel is calibrated to read dew point, not frost point, below 32°.

The system consists of two component units, shown in Figure 1-1: the aspirator and the transmitter. The aspirator is mounted outdoors in a location where it can sample the local atmosphere with a minimum of distractive influences such as ground water, vegetation, etc. The transmitter is located within 5 feet of the aspirator, and is designed to be weatherproof. A fiber optic cable connects the transmitter to the Data Control Package (DCP).

There are many ways in which dew point measurements can be made. The most usual method is by using a "sling psychrometer" which consists simply of a dry- and wet-bulb thermometer pair which the operator slings over his head for a minute or so, to make wet and dry bulb temperature readings. He then converts the data by reference to a standard chart to determine dew point. This method, although cumbersome, is still the standard backup for most electronic systems.

Other more direct methods of measuring dew point include lithium chloride dew cells, and nuclear detector cells. All of the aforementioned methods have a common drawback, however; they measure dew point in an indirect manner. They all enable the operator to compute dew point in terms of side effects such as air moisture content, electrical conductivity, relative humidity, etc.

The chilled mirror hygrothermometer method as used in the Model 1088 and others is unique in that it measures dew point directly, in accordance with the basic definition of dew point. By definition, the dew point of a sample of air is the temperature to which the air must be lowered to make

the vapor become just visible by condensation. In the chilled mirror system, a mirror is held at the temperature at which a fine film of condensate is present on the surface without increasing or decreasing in thickness. With a mirror maintained at precisely this temperature, it is a simple matter to read the mirror surface temperature and display that temperature as the dew point.

Internal circuits of the Model 1088 include a means of refrigerating a small mirror, and by way of an optical feedback loop, maintaining the mirror at exactly the temperature at which the mirror surface is slightly clouded with condensed water vapor from the sampled air. A precision thermal sensor imbedded in the mirror provides the basis for making the temperature measurement. A similar thermal sensor located in the surrounding air indicates the ambient temperature.

1-3. RELATIONSHIP OF UNITS

Figure 1-1 shows the physical relationships of the main hardware units of the 1088.

1-4. REFERENCE DATA

Table 1-1 gives the performance specifications data for the two main hardware units of the 1088.

1-5. EQUIPMENT SUPPLIED

Table 1-2 lists the equipment supplied with a typical 1088 system.

1-6. EQUIPMENT REQUIRED, NOT SUPPLIED

Table 1-3 lists the equipment that is required to install and maintain the 1088, but not supplied with the system.

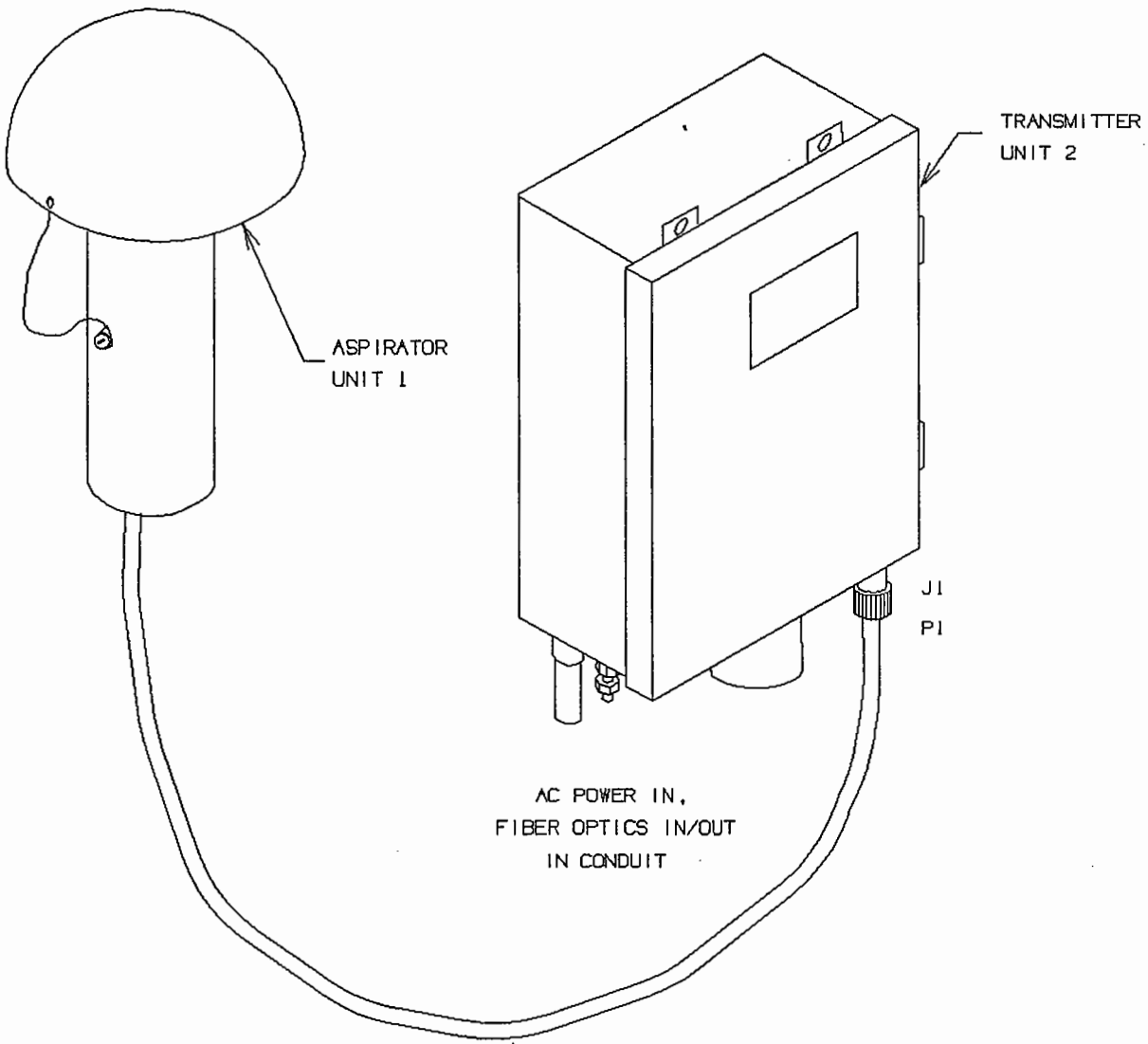

FIGURE 1-1

RELATIONSHIP OF UNITS

1. ASPIRATOR/SENSOR UNIT

Power:	120 VAC, 60Hz, 0.2 amp Supplied by Transmitter
Environment	
Temperature:	-80 to +130° F
Relative Humidity:	5 to 100 %
Wind:	Operational to 30 Knots
Ice Loading:	To 1 inch Note: Ice or snow cap may affect accuracy; but equipment will return to normal operation after removal of ice or snow.
Accuracy:	
Ambient Temperature:	+/- .5°, -58 to +122° F. +/- 1° through the remainder of the range.
Dew Point:	+/- 2° F RMSE, +30 to +86° F. +/- 3° F RMSE, -10 to +30° F. +/- 4° F RMSE, -30 to -10° F.
Sensitivity:	0.1°.

2. TRANSMITTER UNIT

Output Signal:	RS-232C
Signal Rate:	600 Baud
Output Loading	600 Ohms, nominal
Sample Rate:	Output on demand
Input Power:	120 VAC, 60 Hz, 1.0 ampere,nominal.
Environment:	Same as for Aspirator

Table 1-1

EQUIPMENT SPECIFICATIONS

Quantity	Unit Name	Weight and Dimensions (Uncrated)	
1	Aspirator	18" L 11" W 11" D 7 Lbs.	
1	Transmitter	With Mounting Collar 19" H 12" W 6" D 28 Lbs.	W/O Mounting Collar 14" H 12" W 6" D 22 Lbs.
1	Mounting Pole	41" L 8" W 8" D 15 Lbs.	
1	Mounting Kit (Mounting Struts, Tie-Wraps, and and Hardware)	24" L 2" W 2" D 4 Lbs.	
1	Sun Shield	16" L 13" W 13" D 3 Lbs.	

Table 1-2

EQUIPMENT SUPPLIED WITH SYSTEM

CATEGORY	RECOMMENDED EQUIPMENT
POWER CABLE	PER INSTALLATION SPECS
COMMUNICATION CABLES	PER INSTALLATION SPECS
DIGITAL VOLT-OHMETER	SIMPSON 465 OR EQUAL
OSCILLOSCOPE	TEKTRONIX T922 OR EQUAL

TABLE 1-3

EQUIPMENT REQUIRED, NOT SUPPLIED

SECTION 2

OPERATION

2-1. INTRODUCTION

This section provides the operator of the system with all information needed to use the equipment.

2-2. OPERATORS' DATA TABLE

After the equipment is installed and initially set up, operation is fully automatic, requiring only occasional maintenance service. Table 2-1 and Figure 2-1 describe all switches, controls, adjustments, and indicators that are available to the user. All of the accessible adjustments are located in the transmitter unit.

TABLE 2-1

CONTROLS, INDICATORS, ADJUSTMENTS

On the transmitter unit control panel:

AC POWER ON/OFF (1) Energizes both the transmitter and aspirator units.

MODE SELECTOR SWITCH (2) Selects various test modes for servicing. This switch is normally in the Operate (OPR) position. The functions may be selected by manual operation of this switch, or by commands received from the remote data collection processor. The switch positions are:

OPR The hygrothermometer functions normally.

TEST 0 Precision resistors are substituted for the dew point and ambient sensors simulating 32 degrees Fahrenheit temperatures. This mode is used when adjusting the instrument for a precise zero reading.

TEST 50 Precision resistors are substituted for the temperature sensors, simulating +122 degrees Fahrenheit for instrument span adjustment. The monitor display indicates only the lower digits (22.0).

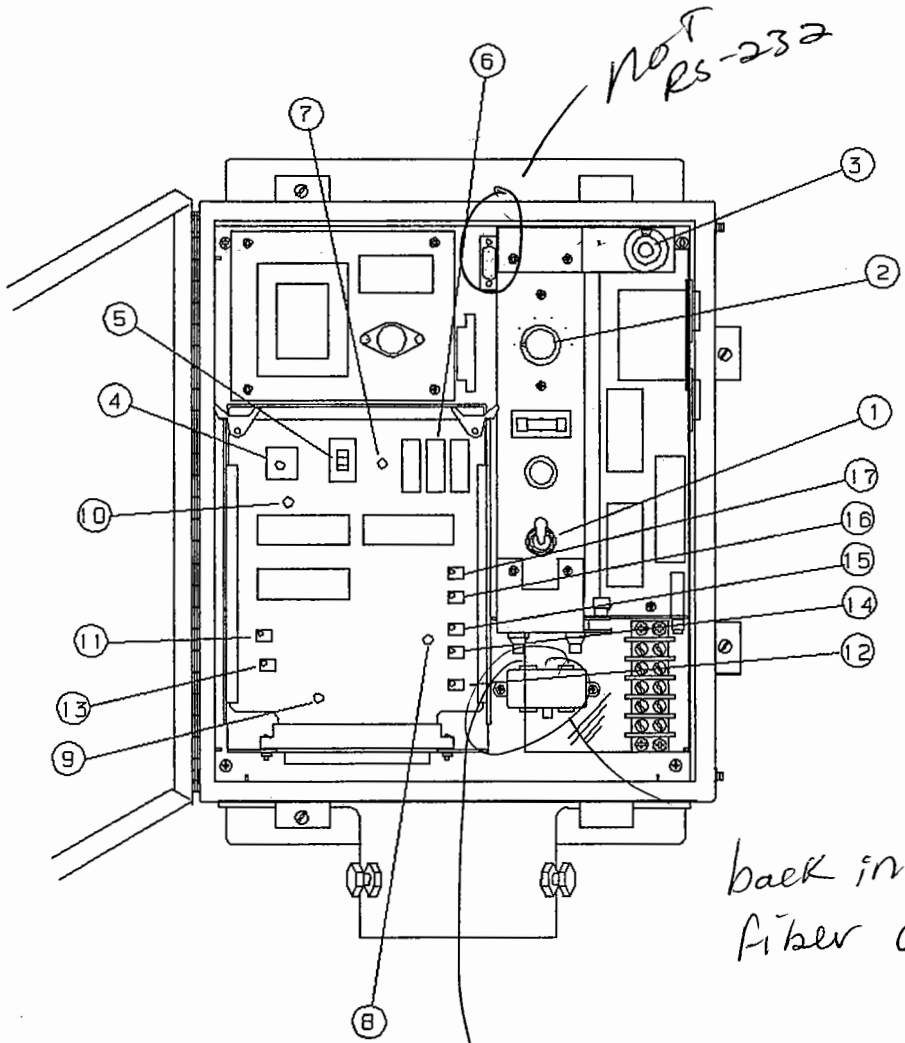

FIGURE 2-1

CONTROLS, INDICATORS, ADJUSTMENTS

SENSOR TEST The mirror cooling power is interrupted, permitting the mirror temperature to drift up to ambient. After a few minutes in this mode, the dew point and ambient temperature indications should be equal, indicating that both temperature sensors are very probably OK.

COOL Full cooling power is applied to the mirror, for test purposes.

HEAT Full heating power is applied to the mirror. This mode is used to clear the mirror of condensate or frost for test or adjustments.

AUTOBALANCE DIAL (3) This dial serves both as an indication of the Autobalance shaft position and a means of manually setting the Autobalance, usually to zero.

On the Transmit Logic Printed Circuit Assembly:

MONITOR DISPLAY SWITCH (4) When depressed, causes the monitor display to indicate current dew point or ambient temperature, as selected by the MONITOR DISPLAY SELECTOR SWITCH (5) . It should be noted that the data displayed is derived from the same RS232C serial signal which is delivered to the remote data processor. When the Monitor Display Switch is depressed, communication between the transmitter and the remote data processor is interrupted.

MONITOR DISPLAY (6) A three-digit display of dew point or ambient temperature in degrees Fahrenheit. Polarity of the temperature is indicated by the NEGATIVE POLARITY LED (7) .

DIRECT SENSOR LED (8) Indicates when the direct optical signal, Sd, is above a threshold level. With a dry mirror, this indicator is normally ON. During operation, this indicator is normally OFF, or flickering.

INDIRECT SENSOR LED (9) Indicates when the indirect optical signal, Si, is above a threshold level. With a dry mirror, this indicator should be OFF. In normal operation, this indicator is ON.

FAN FAIL LED (10) This LED comes on if the aspirator fan fails, or if the aspirator air flow is otherwise impeded.

FAN FAIL ADJUSTMENT (11) With normal air flow, this trimpot is adjusted to extinguish the FAN FAIL LED. When properly adjusted, the failure indication should come on when the output air flow of the aspirator is blocked.

DIRECT SENSOR ADJUSTMENT (12) This trimpot is adjusted to cause the Sd indicator to come on when the mirror is dry, and the Autobalance dial is turned to 000.

INDIRECT SENSOR ADJUSTMENT (13) This trimpot is adjusted to bring the Si indicator just below the ON threshold when the mirror is dry, and the Autobalance dial is turned 000.

TAO ADJUSTMENT (14) This trimpot is adjusted to trim the ambient temperature indication to exactly 32.0 when the mode switch is in the TEST 0 position.

TA+ ADJUSTMENT (15) This trimpot is adjusted to trim the ambient temperature indication to exactly +22.0 when the mode switch is in the TEST 50 position.

TDO ADJUSTMENT (16) This trimpot is adjusted to trim the dew point indication to exactly 32.0 when the mode switch is in the TEST 0 position.

TD+ ADJUSTMENT (17) This trimpot is adjusted to trim the dew point temperature indication to exactly 22.0 when the mode switch is in the TEST 50 position.

2-3. OPERATION

2-3.1 General: After installation and initial adjustments are made, operation is automatic and remotely controlled, requiring no manual intervention. The instrument tracks dew point and ambient temperatures constantly, providing a data readout only when requested by the remote controlling processor. All of the standard test modes can be called up manually from the remote site, for evaluation and some degree of troubleshooting.

2-3.2 Routine Maintenance: The only routine maintenance required is a periodic cleaning of the chilled mirror element. Figure 2-2 illustrates the location of the mirror in the aspirator assembly. This may be required as often as once every 30 days, or as infrequently as twice per year, depending entirely upon the type and degree of contaminants in the local atmosphere. As a matter of routine, each time the mirror is serviced, the Autobalance should be reset to 000, and all of the adjustments should be checked and trimmed as necessary.

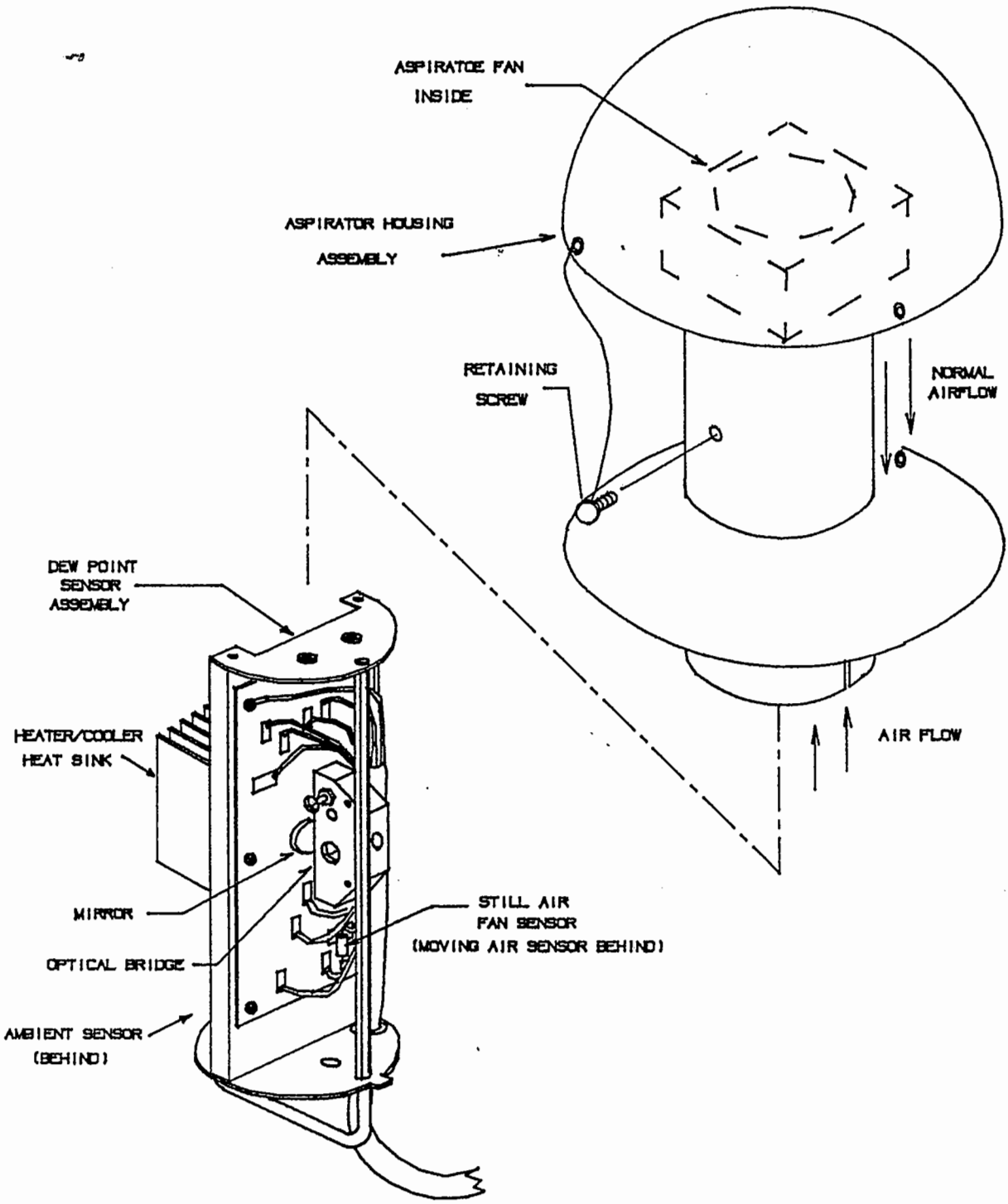

FIGURE 2-2
ASPIRATOR INTERIOR

2-3.3 Mirror Cleaning: When it is necessary to clean the mirror, the following procedure should be followed:

(a) Heat the mirror above ambient temperature. Turn off the AC power. Set the autobalance dial to the 000 position.

(b) Using a clean cotton swab and distilled water, thoroughly wet the mirror surface and then wash with a gentle circular motion. Immediately wipe the wet surface with a clean dry swab until dry and all loosened material removed. Continue the wet swab and dry swab process until it no longer has a cleaning effect. The use of the dry swab is essential to the cleaning process since it removes the loosened contaminants which would otherwise remain on the mirror. For colder temperatures, it may be necessary to disconnect the dew point sensor assembly from the transmitter enclosure and do the cleaning in a warmer place.

(c) Repeat Step (b) using lacquer thinner (acquired from local source). Repeat the wet swab and dry swab process until it no longer has a cleaning effect.

(d) Repeat Step 2 using the approved isopropyl alcohol (ASN 052-C-12). Repeat the wet swab and dry swab process until it no longer has a cleaning effect.

(e) Reapply AC power. Heat mirror to 20 degrees F above ambient temperature or 52 degrees F, whichever is higher. Perform the optical adjustments.

Under no circumstances should soap or other detergent be used on the mirror, as this may have an effect on the formation of condensate required in the normal operation of the chilled mirror instrument.

2-4 OPTICAL ADJUSTMENTS

2-4.1 Optical Adjustments: After the mirror has been satisfactorily cleaned, ensure that AC power is off.

The optical adjustments must be performed in a stable dew point environment; therefore, the following set up is required:

(a) Pull the dew point sensor assembly from the aspirator housing assembly. Visually inspect the mirror to ensure that the mirror is dry.

(b) Place the dew point sensor assembly in a cardboard box.

(c) Place the box with the sensor in a large plastic bag.

(d) Set up a digital voltmeter to measure 5 VDC. Connect the positive lead to the left side of R3 (junction of R8, R3, and C2) on the Transmit Logic P.C. Board. Connect the negative lead to ground.

(e) Reapply AC power. Proceed immediately to 2-4.1.1.

2-4.1.1 Dry Mirror Adjustments: All of the adjustments in this section must be done with a completely dry mirror. Insure a dry mirror by heating the mirror for a minimum of 1 minute initially and then keeping the mirror temperature above ambient (Ta) using the manual heat/cool switch. The measurements and adjustments described below (3A and 3B) must not be made while heating the mirror. It is therfore necessary to monitor the mirror temperature (Td) and heat as necessary to maintain Td greater than Ta, making the measurements and adjustments between the heating cycles.

(a) Turn the Sd gain adjustment (R21) CW until the Sd LED (CR5) just goes on (threshold level). The voltmeter should read approximately 4.9 volts.

Should come back on.

(b) Adjust the Si gain adjustment (R22) CW until the Si LED (CR9) goes on and then back off the Si gain until the Si LED just goes off. let stabilize - better not have 4.9

2-4.1.2 Dew Layer Adjustments: The measurements and adjustments of this section are made with a dew layer on the mirror. The Si gain is adjusted to give a proper dew layer by monitoring the Sd level.

OPK

(a) Allow the system to stabilize at dew point.

(b) Adjust the Si gain adjustment CCW until the voltage at the left side of R3 (same point as previous measurement) reads 3.9 +/ 0.1 VDC. This adjustment is critical and extreme care has to be exercised since this is a dynamic situation with the dew layer thickness changing slowly. During the adjustment, allow the layer to reach equilibrium each time prior to making a correction adjustment. The optic loop adjustment is complete when 3.9 +/- 0.1 VDC is obtained and stable.

The optical adjustments are now complete. Remove the dew point sensor assembly from the plastic bag and box and install it in the aspirator housing assembly. Return the mode switch to OPR. The instrument will now drive the mirror temperature down to the dew point and stabilize. Depending on the dew point temperature, this may take several minutes. After stabilization, the instrument will continuously track the dew point.

2-4.2 Instrument Calibration: Calibration of the instrument electronics may be checked by use of the TEST 0 and TEST 50 positions of the mode switch. In the TEST 0 position, Ta and Td should read 32.0 on the monitor display, when the display switch is depressed. If necessary, adjust the TA0 and TD0 trimpots for 32.0 +/- 0.1 degrees. In the TEST 50, the two channels should read 22.0. If necessary, adjust the TA+ and TD+ trimpots for 22.0 +/- 0.1 degrees.

2-4.3 Airflow Sensor Adjustment: Adjust the FAN FAIL trimpot CCW until the FAN FAIL LED comes on. Turn the trimpot slowly CW until the LED goes off, then one additional turn CW. Verify operation by blocking the aspirator intake (on the bottom). Within about 30 seconds, the FAN FAIL LED should come on. When the blockage is removed, the LED should extinguish within 30 seconds.

2-4.4 Autobalance Operation: Operation of the Autobalance is automatic. Once per day, the mirror is heated for approximately 8 minutes, and the Autobalance makes the necessary electrical adjustment to compensate for mirror contamination. As the mirror surface becomes more contaminated, the position of the Autobalance dial increases. When the dial reaches an indication of approximately 500, an error signal is transmitted with the data, signalling that the mirror needs cleaning. With the compensating effect of the Autobalance, and in a reasonably clean atmosphere, the instrument may have an expectancy of 6 months or more between mirror cleaning requests.

2-5 REMOTE CONTROL OPERATION

2-5.1 General: A readout of ambient and dew point temperatures is available whenever the system is interrogated. At selected times, routine tests are performed and the results are recorded. All of the instructions and data requests are made by way of the RS-232C serial data link between the hygrothermometer and the controlling processor. A two-way link is used - one way for the requests, and the return link for the data messages. Refer to Figure 2-3 for the serial data format.

CS
SDM-5104

Bart 435-750-9551

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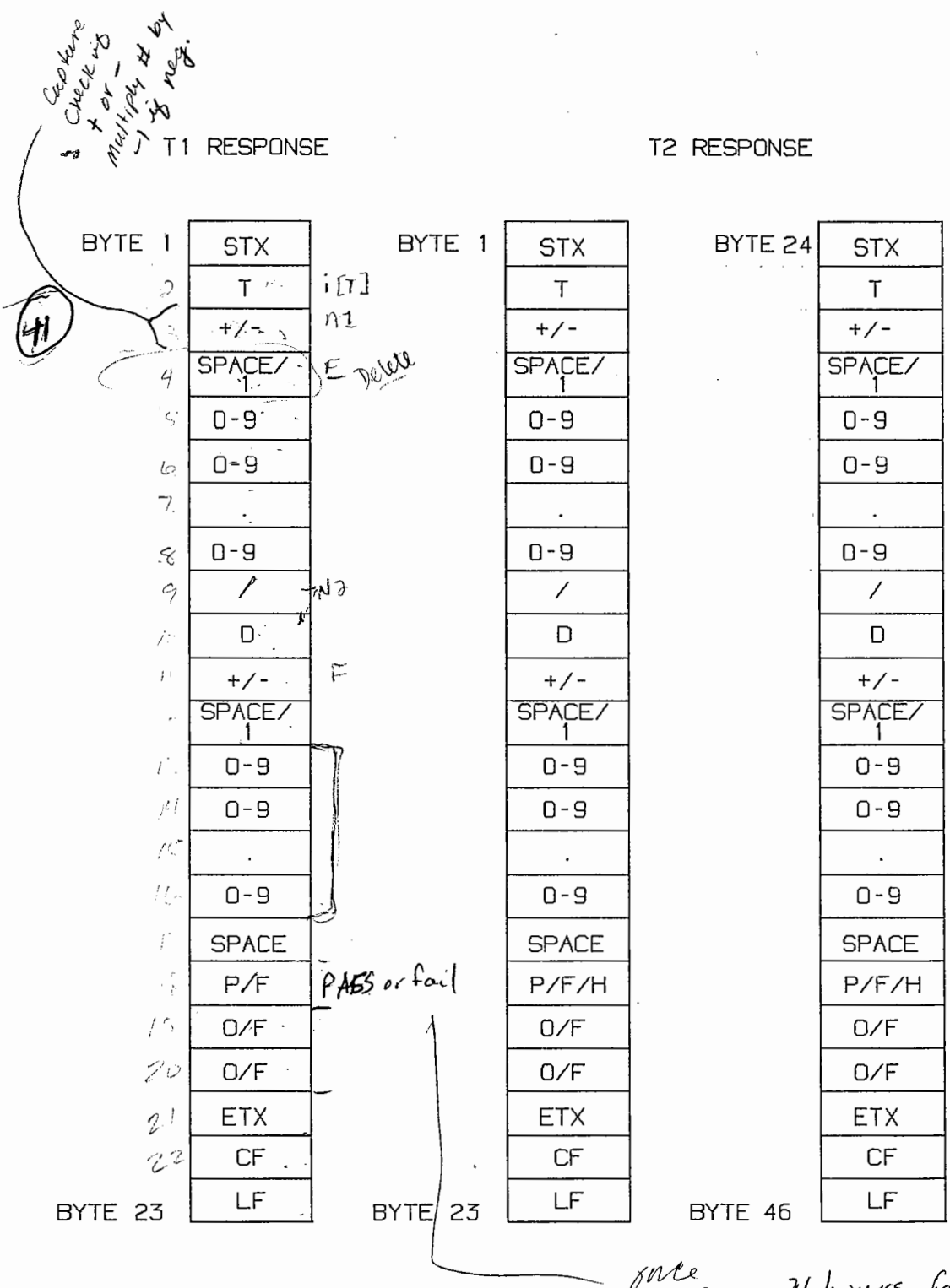

FIGURE 2-3

SERIAL DATA FORMAT

~~at~~ turn on at noon.

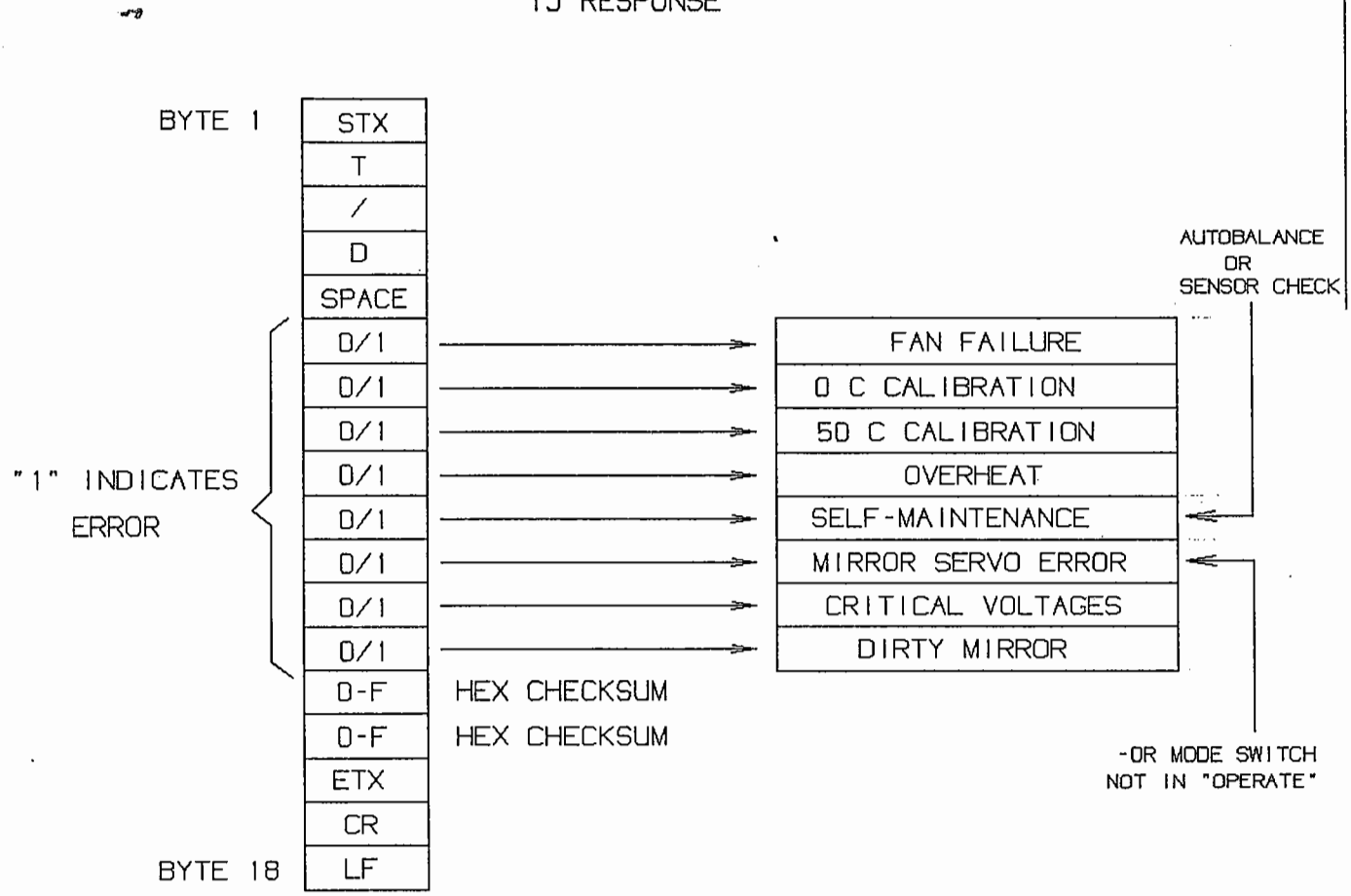

FIGURE 2-3

SERIAL DATA FORMAT

(CONTINUED)

T4 RESPONSE

BYTE 1	STX
	T
	/
	D
	SPACE
	T
	E
	S
	T
	2
	7
	ETX
	CR
BYTE 14	LF

T5 RESPONSE

BYTE 1	STX
	T
	/
	D
	SPACE
	T
	4
	SPACE
	C
	O
	M
	P
	L
	E
	T
	E
	8
	ETX
	CR
BYTE 20	LF

FIGURE 2-3

SERIAL DATA FORMAT

(CONTINUED)

2-5.1 Control Messages: By way of simple characters, the remote processor can call up a data message or any one of several diagnostic actions. The standard messages are:

Command	Response
T1	Send a standard readout of temperature (Ta), dew point (Td), and error flag. The error flag is a single bit which indicates the presence of any one or more of the 8 standard error conditions. The error flag is normally off.
T2	Send simulation data. This places the instrument in the TEST 0, then the TEST 50 mode. Instrument sends data representing Ta @ 32.0, Td @ 32.0, Ta @ +122.0, and Td @ +122.0. Error flag is ON.
T3	Send error message. This is a listing which tabulates the status of the 8 standard error conditions which are automatically monitored. These are:

Byte 6 - Fan or airflow failure.

Byte 7 - Error at 00 degree calibration.

Byte 8 - Error at +50 degree calibration.

Byte 9 - Mirror overheat.

Byte 10 - Self-maintenance cycle in process. This can be Autobalance or Sensor Test.

Byte 11 - Mirror Servo error, or Mode switch not in OPR position.

Byte 12 - Critical supply voltage out of tolerance.

Byte 13 - Dirty mirror. Operation may be tested by manually turning the Autobalance dial to 500. At a value between 450 and 550, the Dirty Mirror error bit should come on, and should go off when the dial setting is reduced below 400.

T4	Disable mirror cooling/heating power. This places the system in the SENSOR TEST mode until the command is cancelled by a T5 command.
T5	Cancels the T4 command to again enable the mirror cooling/heating power.

All of the "T" commands can be written into the controlling program; all but the T4 and T5 commands are routinely used. T4 and T5 are used only occasionally when a sensor failure or error is suspected.

THEORY OF OPERATION

3-1. INTRODUCTION

This section gives a detailed explanation of how the 1088 Hygrothermometer converts physical stimuli (Temperature, Dew Point) as received in the Aspirator Unit into usable data for the operator or for the data collection processor.

Description of operation is broken into several separate functional areas. All of the descriptive data given in this section is pertinent and accurate, although the circuit descriptions have been simplified to show only the basic functional elements. For a detailed treatment of circuit operation, the reader is directed to Section 6, in which the circuits are analyzed down to the lowest component level.

3-2. THERMAL CONTROL LOOP

Figure 3-1 describes the elements of the feedback loop which maintains the mirror at the dew point temperature.

A light beam from a small LED, CR1, is directed at the surface of a mirror at an angle of 45 degrees. Two phototransistors, Q1 and Q2, are mounted to receive the reflected light as shown. Q1, the "direct" sensor, is placed so that it receives a high degree of light when the mirror is clear. Q2, the "indirect" sensor, is located so that it is sensitive to light which is scattered when the mirror is clouded with visible condensation. As the degree of cloudiness of the mirror surface increases, Q1 tends to receive less light and Q2 tends to receive more light. The illumination from CR1 is infrared, therefore is invisible to the eye.

Following Q1 and Q2 are a pair of identical signal amplifier-detectors, U5A and U6A, which drive control amplifier, U6B. The output of this high-gain amplifier is negative when the mirror is clear, and positive when the mirror is heavily clouded, because of the difference between the outputs of Q1 and Q2.

The output of U6B, through a power amplifier, drives the mirror colling module, U1. This device is an electronic heat pump, operating much like a thermocouple in reverse.

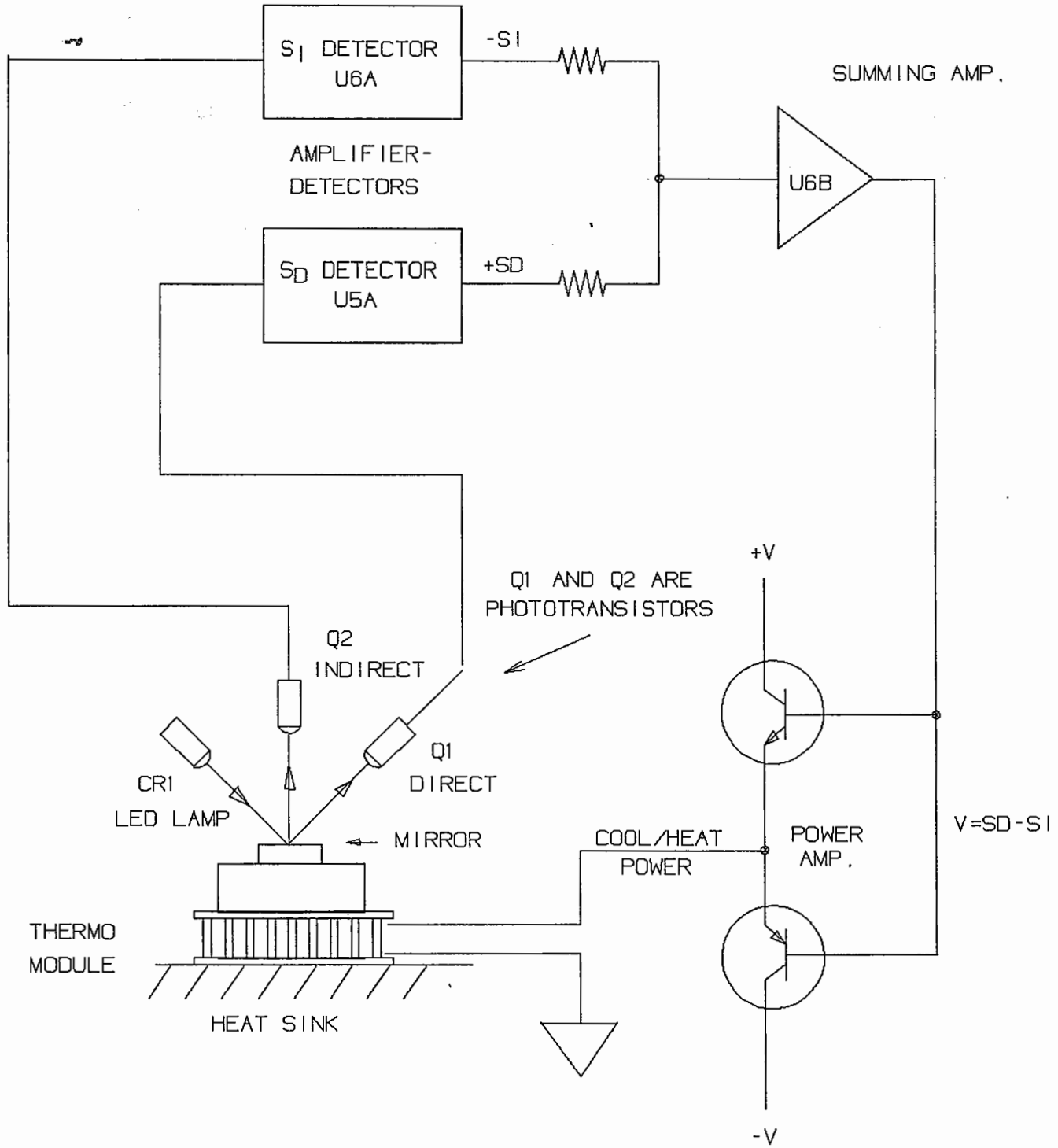

FIGURE 3-1

THERMAL CONTROL LOOP

With a DC voltage applied across its terminals, the module produces a temperature difference between its upper and lower surfaces. Depending on the polarity of the applied voltage, the thermal module can produce a heating or cooling effect.

The feedback loop is effectively closed by the physical phenomenon of formation of condensate on the mirror as the mirror is cooled by the thermal module. When the unit is first turned on, the mirror is clear and photosensor Q1 receives a high level of directly reflected light, and Q2 receives no scattered light. This condition causes a large negative unbalance signal at the output of U6B, causing a heavy current to flow through the thermal module in the cooling direction. The unbalanced condition remains, typically for about one minute, until the mirror surface temperature has reached the dew point temperature. At the dew point, the output of Q1 decreases and the output of Q2 increases because of the visible effect of condensation on the mirror. The system now stabilizes at the dew point temperature, maintaining just enough cooling effect to keep the signal levels from Q1 and Q2 in balance, with U6B and the power amplifier supplying just enough cooling current to maintain the mirror temperature at the dew point. If the dew point of the air should change, or if the circuit should be disturbed by noise, the loop makes the necessary corrections to re-stabilize at the dew point. The system is designed for continuous operation.

The simplified circuitry described by Figure 3-1 is the heart of the hygrothermometer. All that remains to make this a useful instrument is a means of measuring and displaying the mirror temperature.

3-3. TEMPERATURE MEASUREMENT

In the Model 1088, two temperatures are measured and remotely displayed, ambient (Ta) and dew point (Td). The measurement circuits for the two channels are identical.

Figure 3-2 illustrates all of the circuitry involved in producing two output DC voltage levels which precisely represent Ta and Td. The basic sensor for temperature measurement is a platinum wire resistor called an RTD, for Resistance-Temperature Device. At a temperature of 0 degrees C, the RTD has an electrical resistance of exactly 100 ohms. The resistance varies linearly with temperature, at a rate of .392 percent per degree C.

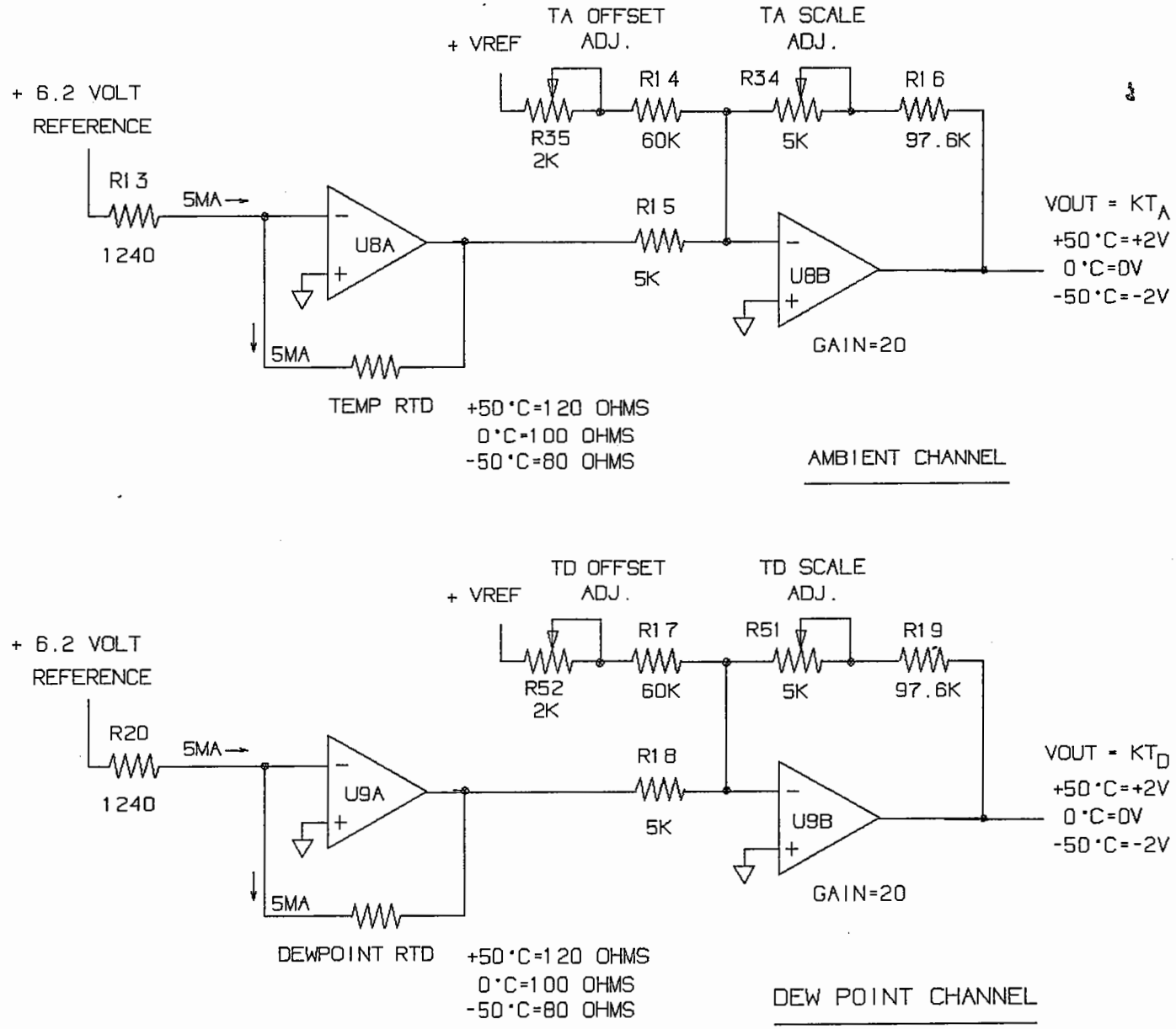

FIGURE 3-2

TEMPERATURE MEASUREMENTS

In our application, a constant DC current of 5 milliamperes flows through the RTD, and the resulting voltage drop across the sensor is used as the temperature signal. In the Ta channel of Figure 3-2, amplifier U8A is used as the constant 5 milliampere source through the RTD. The RTD in this example would be located in the stream of air entering the aspirator unit, so that it would assume the temperature of the ambient air. U8B is used as a scaling and offset adjustment amplifier, setting the output voltage level at a convenient value.

Two DC currents feed the node of U8A, a 5 ma reference input from a 6.2 volt reference voltage source through a precise 1240 ohm resistor, and a feedback current of opposite polarity equal to U8A output voltage through the RTD. By standard operational amplifier analysis, one can see that the feedback loop will force the feedback current to be equal to the 5 ma input current. Since the node of the op-amp, pin 1, is at virtually zero, the U8A output voltage must be equal to .005 x R1 volts. This would give us an output voltage equal to -.5 volt DC at 0 C, -0.4 volts at -50 C, and -.6 volts at +50 C. These values could be used directly for measurement and display purposes, however, they are amplified, inverted and offset by U8B to a more convenient scale. U8B is a conventional inverting op-amp with a gain factor of 20X by virtue of the ratio of the feedback resistance, R34 and R16, and the input resistor, R15. The gain, or scale factor, is slightly adjustable by varying the setting of R34. This is used as a calibration adjustment. The input offset value (-0.5 volt at 0 C) is cancelled out by the signal through R35 and R14. Potentiometer R35 is adjusted to bring the output of U8B to zero at 0 C. At the output of U8B, the signal level vs temperature relationship is 25 degrees per volt, with 0 volts representing 0 degrees C. A temperature of plus or minus 50 degrees C would be represented by plus or minus 2 volts DC at the output.

The dew point temperature measurement channel is identical in all respects, except that the dew point RTD is physically located inside the body of the mirror, so that it assumes the temperature of the mirror, which is constantly held at the dew point temperature, by the optical control loop.

In a simpler hygrothermometer system, the outputs of U8 and U9 could be connected to a pair of voltmeters and the system would be complete. The Model 1088, however, has been designed for capability of displaying the outputs at a great distance from the sensors, so a means of transmitting the outputs must be provided which is insensitive to the effects of line length, noise and other sources of errors. A fiber optic modem is used to transmit data from the Model 1088 to a data collection unit.

3-4. DATA MANAGEMENT

Besides simply transmitting the two analog temperature signals to remote indicators, certain other operations must be performed on the data. Because of the complexity of circuits which would be required for these operations, a microprocessor is used for all of the necessary data control processes. In the transmitter unit, the two analog signals, Ta and Td, are converted to binary digital words and fed to the input of a microprocessor unit (MPU). This MPU is used mainly as a formatting device, converting the input data into a serial format suitable for transmission over long distance telephone equipment. As an additional function, the MPU also performs certain data quality checks as a safeguard against effects of detectable errors, and controls a built in test and error reporting system.

3-5. ANALOG-TO-DIGITAL CONVERSION

A single A-to-D converter, type 7109, is used for the Ta and Td data, so a means must be included for time-sharing or multiplexing the converter input. The multiplex gates and the A-to-D converter connections are shown on Figure 3-3.

3-6. DATA MULTIPLEX

Two CMOS gates are used to selectively connect Ta and Td to the input to the converter. The gates are, in effect, series switches, each controlled by a select line. When the control line to a gate is in the low (0) state, the gate has an effective resistance of hundreds of megohms to the signal. When the control line is high (+5v), the gate presents a resistance of about 50 ohms, connecting the signal to the converter. The two gate outputs are tied together, and their control inputs are complimentary, so that at any given time one of the two inputs is connected to the converter.

Operation of the converter is automatic, as described by the 7109 data sheet. When the RUN/HOLD line from the MPU to the converter is in the RUN condition, the analog input controls the generation of a parallel 12-bit binary representation of the input quantity, with an additional bit indicating the polarity of the input. The 11 most significant bits and the polarity bit are hard wired to appropriate inputs of the MPU.

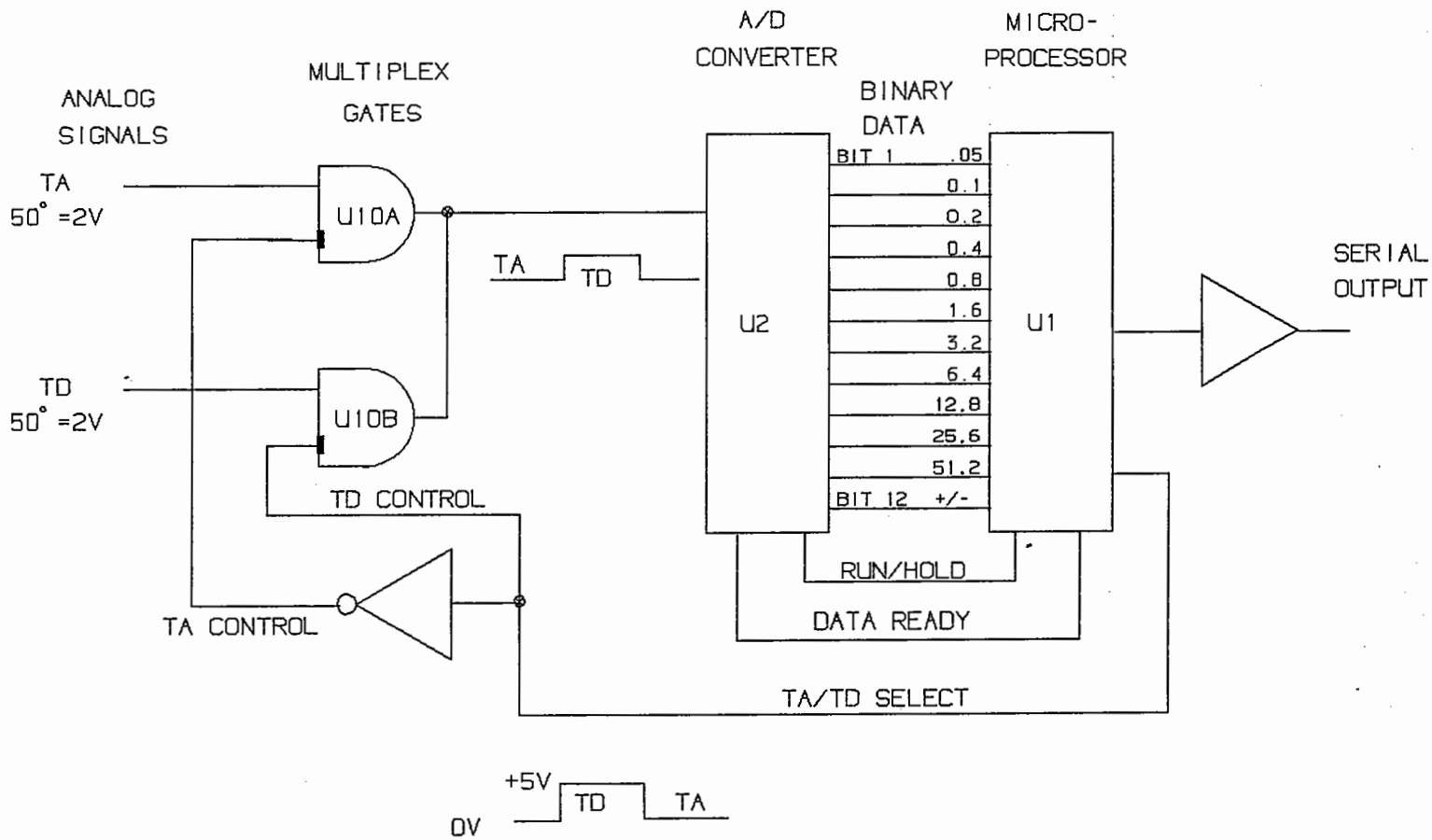

FIGURE 3-3
DATA CONVERSION

the input quantity, with an additional bit indicating the polarity of the input. The 11 most significant bits and the polarity bit are hard wired to appropriate inputs of the MPU.

Conversion requires about 30 milliseconds, depending on the data value. To prevent data transfer to the MPU occuring during the conversion time, a STATUS line from the converter is used as a signal to indicate to the MPU that data is stable and available after each conversion. When the STATUS line is high, the MPU may request new data values. Likewise, after the MPU has processed an input data word, it raises the RUN/HOLD line to signal the converter that a new conversion may begin. This exchange of control signals is called a "handshake" process.

After the MPU has processed an input sample, it reverses the state of the multiplex control line to the analog gates. If the data sample had been Ta, the next condition of the control line would be to enable the Td gate, and vice versa.

3-7. DATA TRANSMISSION

In the MPU, the output data words Ta and Td are temporarily stored. When requested by the remote data control processor, an output data message is assembled and transmitted in RS-232C serial format at a 600 Baud rate. The data requests are received by one-half of a 145405 chip and the data output transmission is handled by the other half of the two-way IC chip.

SECTION 4

SCHEDULED MAINTENANCE

4-1. INTRODUCTION

This section furnishes the technician with all information necessary to perform periodic maintenance that will keep the system operating properly. The system is designed in such a manner that scheduled maintenance actions consist mainly of routine housekeeping chores. The mirror maintenance task is listed as a monthly requirement; this schedule will be determined to a great extent by the local climate conditions and the type and amount of contaminants in the air. Monthly is an extreme case; twice yearly may be more of a typical maintenance period.

4-2. SCHEDULED MAINTENANCE ACTION INDEx

Period	Maintenance Action	Reference
Monthly (see above)	Check Aspirator Unit air passages	4-3. b.
	Check Aspirator Unit mirror and clean if necessary	4-3. b.
	Optical Loop Adjustments (Sensor Gain Adjustments)	4-3. b.
Semi-annually	Instrument Calibration	4-4. b.

4-3. PREVENTIVE MAINTENANCE PROCEDURES

a. Safety Precautions

Operating personnel must at all times observe all safety regulations.

b. Aspirator Unit Maintenance

Because of the continuous flow of outside air through the Aspirator Unit, the optical bridge mirror will gradually acquire a film of contamination which, if not removed, will impair performance of the instrument. Periodically, the mirror surface must be examined and cleaned. This operation should be performed at least twice monthly at first, then more or less frequently as indicated by local climate conditions. Also, the air passages of the unit may accumulate obstructions such as leaves, insects, and dust, and should be wiped or blown clear during the mirror cleaning procedure.

Instructions for servicing the mirror are found in section 2-4.2, Mirror Cleaning.

After replacing the sensor assembly in the Aspirator shell, the technician must perform the Adjustments found in section 2-5.

SECTION 5

INSTALLATION

5-1. INTRODUCTION

This section provides the installation technician all information needed for installing the 1088 hygrothermometer. Included in this section are installation drawings; packing, unpacking and preservation instructions; installation procedures; and performance verification procedures.

5-2. INSTALLATION DRAWINGS

The following drawings may be required in the installation process:

a. Mounting plan (Figure 5-1)
b. Interconnecting wiring (Figure 5-2)
c. Controls, Indicators, Adjustments (Figure 5-3)
d. Mirror Location (Figure 5-4)

5-3. MOUNTING INFORMATION

a. Aspirator Unit

The aspirator is supported behind the transmitter by a system of struts as illustrated by Figure 5-1. The electrical cable which makes all necessary connections between the transmitter and the aspirator is supplied with the equipment and requires only plugging into circular connector (J1) on the transmitter case.

b. Transmitter Unit

The transmitter unit is normally mounted on a 3 inch vertical mounting pole that is supplied with the unit. This 42" pole is mated to an existing pedestal at the ASOS site that is located 18" off the ground. Bolts for attaching the mounting pole flange to the pedestal flange are supplied by the installer. A clamping pipe flange is permanently installed as a part of the transmitter case (refer to Figure 5-1); the transmitter unit is held to the mounting pole by two bolts on this flange.

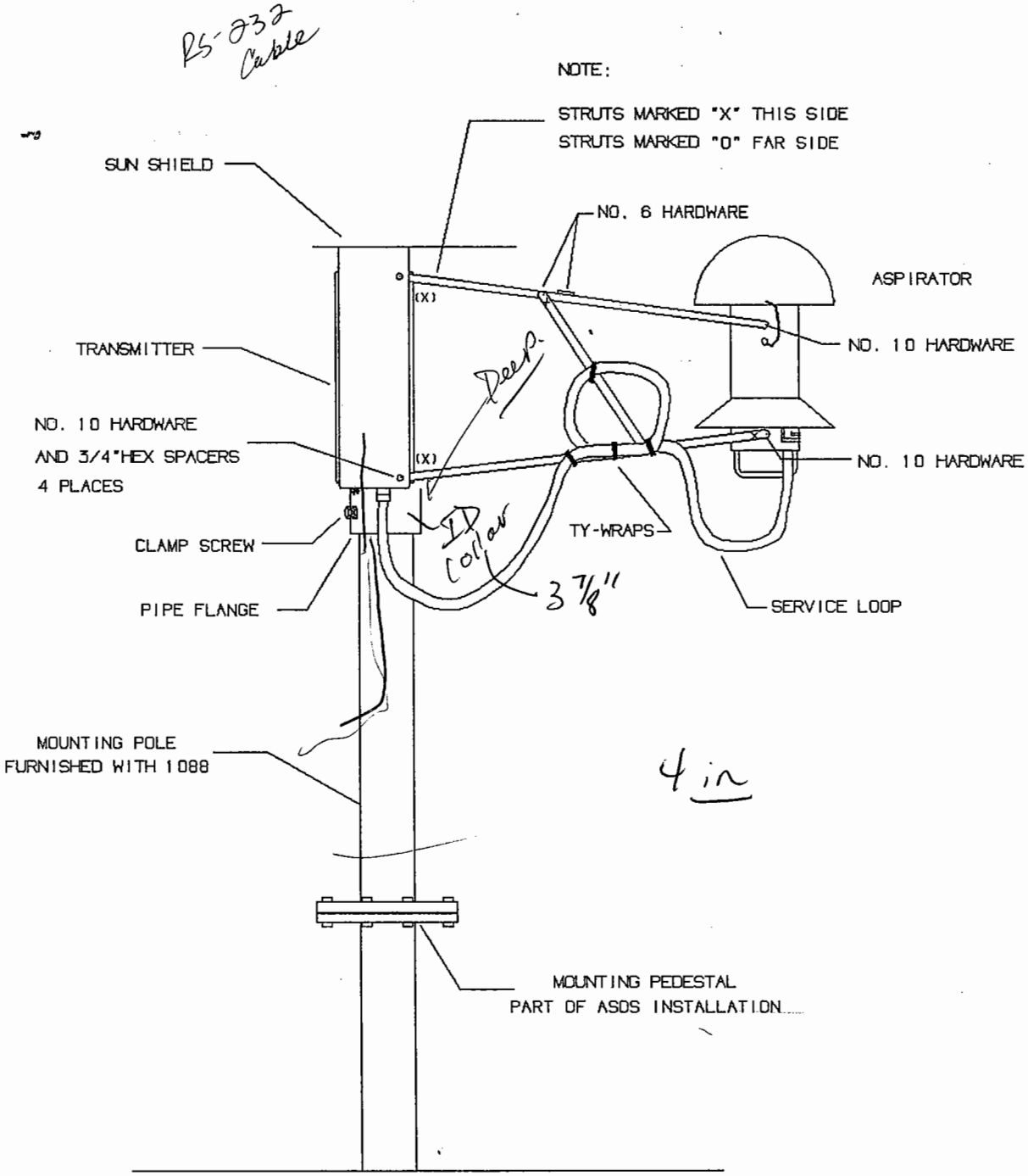

FIGURE 5-1
MOUNTING PLAN

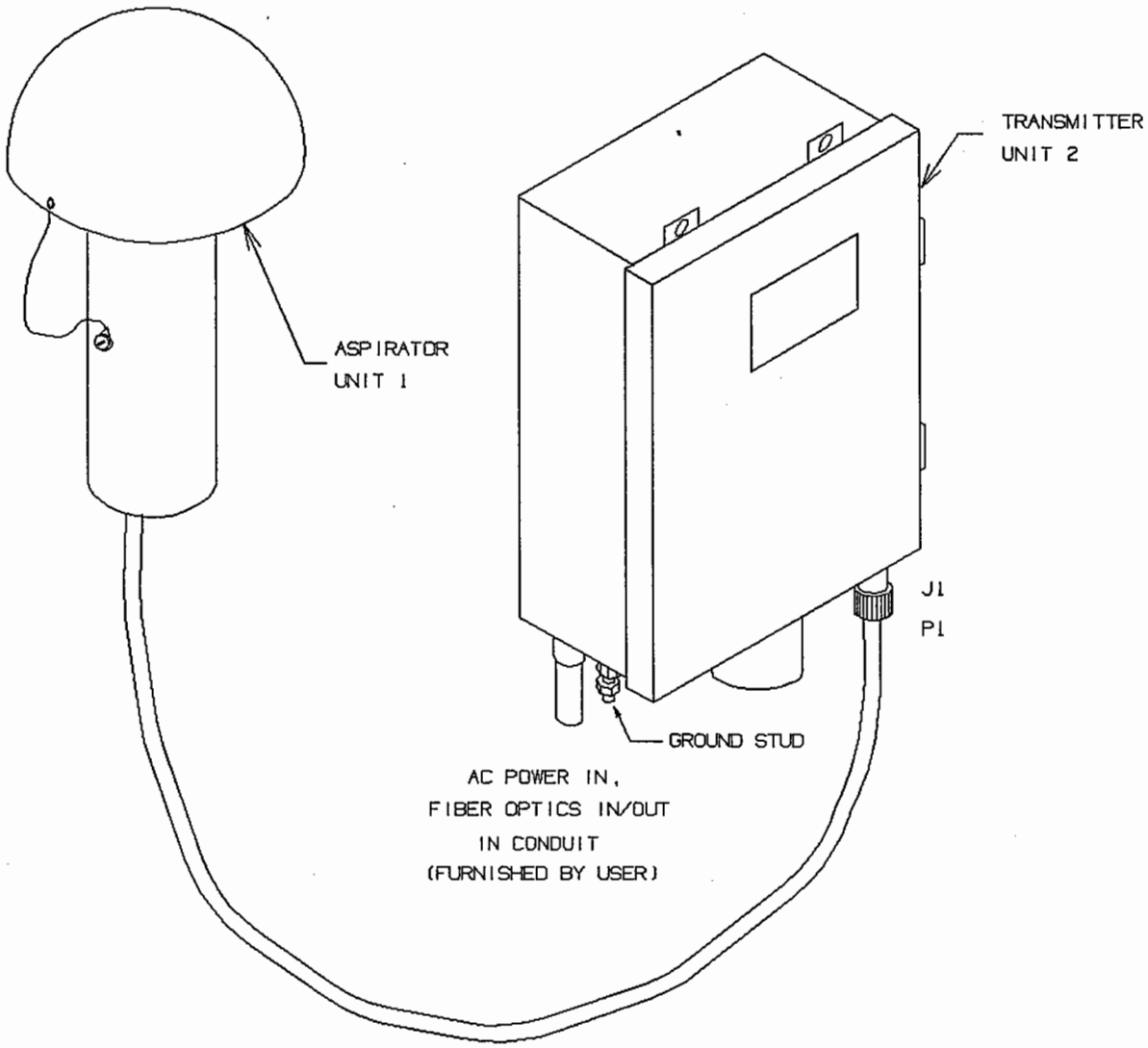

FIGURE 5-2

INTERCONNECTING CABLES

5-4. MATERIALS REQUIRED

All external wiring must be furnished by the installer. See the ASOS installation specification for further details.

5-5. TEST EQUIPMENT REQUIRED

For checking out the installation and performance of the instrument, the following test equipment, or equal, is recommended:

a. Oscilloscope, Tektronix Model T922

b. Digital Volt-Ohm-Milliameter, Simpson 465

c. Glass Thermometer, +/- 0.5 Degree C accuracy

5-6. UNPACKING AND REPACKING

The 1088 instrument is ready for installation when removed from its shipping carton. The carton and packing material may be saved for future repacking as required.

5-7. POWER REQUIREMENTS

Transmitter unit: 120 volts, 60Hz, single phase, approximately 1 ampere.

Aspirator unit: Power is supplied from the transmitter unit by way of the interconnecting cable provided as a part of the instrument.

5-8. INSTALLATION PROCEDURE

Place the mounting pole supplied with the unit on top of the existing pedestal. Fasten the pole to the pedestal with proper hardware. Mount the Transmitter unit on top of the mounting pole and tighten the two bolts on the clamping pipe flange.

Loosely assemble the mounting struts as shown by Figure 5-1. After the struts and the aspirator unit have been mounted on the studs on the transmitter unit, tighten all hardware. Connect the aspirator cable to receptacle J1 on the transmitter unit. Connect the existing grounding wire at the site to the bolt marked "GROUND" on the transmitter unit.

Consult the site installation instructions for connecting the fiber optic and power cables to the transmitter unit.

5-9. INSTALLATION CHECKOUT

The following installation checkout procedure is used to ensure that the equipment has been properly installed and the system is ready for unattended operation. Refer to Figure 5-3 for location of all controls, adjustments, and indicators.

5-9.1 Pre-power Checks: After the system has been installed, verify the following:

All components have been installed and connected in accordance with Figures 5-1 and 5-2.

Test equipment is available and calibrated.

There are no obstructions to air flow through the aspirator. Normal air flow is into the bottom of the aspirator, upward through the aspirator tube and out of the dome.

Mode switch on the transmitter control panel is in the OPR position.

The Autobalance dial is turned to 000.

The dew point sensor mirror (in the aspirator) is clean and dry. Figure 2-2 shows the location of the mirror in the aspirator assembly.

5-9.2 Power On Checks: Turn on the transmitter power on. The monitor display should light immediately, and the aspirator fan should immediately start. The fan makes an audible sound.

Place the Mode switch in the HEAT position. Measure the three main DC supply voltages at the Transmit Logic PC card connector. The levels should be +12v, -12v, and +5v at pins 12, 6, and 10 respectively, and all should be within +/- 0.5 volt of the nominal values.

5-9.3 Optical Adjustments/Calibration: Perform the Optical Adjustments, Calibration, and Airflow Sensor Adjustments found in section 2-5.

5-9.4 Instrument Accuracy: Hold a glass thermometer under the bottom of the aspirator tube (below screen) to test the inlet temperature. Allow 1 minute for the glass thermometer to stabilize. The indicated Ta should be within 0.9 degrees Fahrenheit of the glass thermometer indication. To test the Td channel accuracy, place the Mode switch in SENSOR TEST. This disables mirror cooling and allows the mirror temperature (Td) to drift up to ambient (Ta). Allow 10 minutes for the Td indication to stabilize, then compare indicated Td with indicated Ta. The two values should be equal within 1.9 degrees Fahrenheit. Place the Mode switch in OPR and allow the instrument to stabilize. This is the most accurate test that can be applied to the dewpoint channel, unless another precision hygrothermometer is available for a comparison.

5-9.5 Data System Tests: From the remote Data Collection Package (DCP), send the following standard requests while the hygrothermometer is operating normally (see Figure 2-3 for illustration of serial data formats):

Command	Response
T1	Send a standard readout of temperature (Ta), dew point (Td), and error flag. The error flag is a single bit which indicates the presence of any one or more of the 8 standard error conditions. The error flag is normally off.
T2	Send simulation data. This places the instrument in the TEST 0, then the TEST 50 mode. Instrument sends data representing Ta @ 32.0, Td @ 32.0, Ta @ +122.0, and Td @ +122.0. Error flag is ON.

T3 Send error message. This is a listing which tabulates the status of the 8 standard error conditions which are automatically monitored. These are:

Byte 6 - Fan or airflow failure.

Byte 7 - Error at 00 degree calibration.

Byte 8 - Error at +50 degree calibration.

Byte 9 - Mirror overheat.

Byte 10 - Self-maintenance cycle in process. This can be Autobalance or Sensor Test.

Byte 11 - Mirror Servo error, or Mode switch not in OPR position.

Byte 12 - Critical supply voltage out of tolerance.

Byte 13 - Dirty mirror. Operation may be tested by manually turning the Autobalance dial to 500. At a value between 450 and 550, the Dirty Mirror error bit should come on, and should go off when the dial setting is reduced below 400.

T4 Disable mirror cooling/heating power. This places the system in the SENSOR TEST mode until the command is cancelled by a T5 command.

T5 Cancels the T4 command to again enable the mirror cooling/heating power.